Royal Institution of Great Britain.

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29.

WEEKLY EVENING MEETING,

Friday, February 27.

THE DUKE OF NORTHUMBERLAND, F.R.S. President, in the Chair.

DR. LYON PLAYFAIR, C.B., F.R.S.

On three important Chemical Discoveries from the Exhibition of 1851.—A. Mercer's Contraction of Cotton by Alkalies;—B. Young's Paraffine and Mineral Oil from Coal;—C. Schrötter's Amorphous Phosphorus.

[The following statements and arguments were supplied by DR. LYON PLAYFAIR as embodying considerations which he desired to impress on the attention of the Members of the Royal Institution.]

IT is incumbent on those who, like myself, have been connected with the Great Exhibition, to inculcate its teachings in order that it may influence the future, by being a starting point for industry. Unless it imparts new life to productive industry, it has failed in the attainment of its object, and will, in history, degenerate into the record of a gigantic show, fitted only to pander to an idle curiosity. All of us have, no doubt, examined it with a higher object, and have derived lessons varying in character and amount according to the opportunities which we enjoyed in their acquisition. Those who have attended to its teachings with regard to the comparative progress of manufactures in different countries, owe it as a public duty to announce their convictions on a subject of such large social importance.

My official connection with the Exhibition has enabled me to give more attention to it than most of those whom I have the honour to address, and convictions unfavourable to our position, as an industrial nation, have impressed themselves with such force upon my mind, that you will not be surprised that I seize every opportunity of directing public attention to them. I have already done so in a formal manner, on two previous occasions, and I rather depart from the custom of bringing before you subjects of original research at these evening meetings, in order that I may advocate the necessity of a more intimate union between science and practice in this country, at an Institution, whose proudest boast it is to have largely advanced the discovery of abstract truths, while it has always encouraged, at the same time, their applications to the increase of human resources and enjoyments.

In this lecture, however, I shall rather urge this point as a natural

consequence of the subjects chosen for illustration of my argument than by any doctrinal exhortations, because these are not needed to strengthen your general convictions.

Our nation has acquired a proud position among the industrial states of the world, partly by the discoveries of her philosophers, partly by the practical powers and common sense of her population, but chiefly by the abundance and richness of her natural resources. Our fuel is abundant and cheap, and our iron and the lime necessary for its production are associated with it, so that all three may be extracted together under the most favourable circumstances. These local advantages gave to our country enormous powers of production, and, under the favouring influences of an accidental combination, it supplied its produce to the rest of the world. Circumstances remaining the same, our industrial position was secured, and we have been thus lulled into a fatal apathy; for conditions were in fact varying with great rapidity, and the world at large was passing through a state of remarkable transition.

Setting aside the questions of capital and labour, which are not adapted for discussion in this place, the progress of manufactures is made up of two factors, possessing very different values. One of these represents the raw produce,—the other, the intellect or science employed to adapt it to human wants. As civilization advances, the value of the raw material as an element of manufactures diminishes, while that of the intellectual element is much enhanced. Improvements in locomotion by sea and land spread over the world the raw material formerly confined to one locality; and a time arrived when a competition of industry became a competition, not of local advantages, but of intellect.

It was obvious that when improved locomotion gave to all countries raw material at slight differences of cost, that any superiority in the intellectual element would more than balance the difference. The Continental States, acting on a perception of this truth, saw that they could only compete with English industry by instructing their populations in the principles of science. Hence have arisen, in their capitals, in their towns, and even in their villages, institutions for affording a systematic training in science; and industry has been raised from the rank of an empirical art to that of a learned profession. The result is seen in the fact that we now meet most European nations as competitors in all the markets of the world. The result is palpably forced upon us by our actual displacement from markets in which we had a practical monopoly. The result was obvious in the Exhibition, where we saw many nations, formerly unknown as producers, frequently approaching, and often excelling us in manufactures, our own by hereditary and traditional right.

The teaching of the Exhibition was to impress me with the strongest conviction that England, by relying too much on her local advantages, was rapidly losing her former proud position among manufacturing nations; and that unless she speedily adopted measures to cultivate the intellectual element of production, by instructing her population in the scientific principles of the arts which they

profess, she must inevitably and with rapidity lose those sources of power, which, in spite of the smallness of her home territory, have given to her so exalted a rank among nations.

With these convictions you will not be surprised that I have chosen subjects connected with the Exhibition, although I have no merit or part whatever in their discovery. I have selected them for the following reasons.

We have a great reliance on the practical sagacity or common sense of our population,—certainly superior to that of any part of Europe: but we have not strengthened it by communicating scientific knowledge to those who are entrusted with the exercise of this practical power; and, hence, this common sense, unaided by the rules of science, has gradually assumed a sway over our manufactures. In other words, conjectural judgments have usurped the place of systematic knowledge. Practice and science have been followed out separately, as having no immediate connection. This separation, and even practical antagonism, has been fatal to our progress in industry; for manufacturers, as a body, have ceased to perceive that abstract science forms the roots of the tree of industry, and that to separate them is to sever the tree from its roots. In order to restore vigour to our declining industry, it is essential that confidence in the powers of science should be imparted to practice, and that the latter should be taught that it is, even as a question of social policy, highly important to encourage discoveries in abstract truths, however apparently remote from practice; because science only benefits industry by its overflowings, arising from the very fulness of its measure.

Every abstract truth, in its due time, adds to human resources and enjoyments, and it is this text that I wish to inculcate from examples derived from the Exhibition. One of the last generalizations of the great Berzelius, was that of *allotropism*, a name only eleven years old, and fully explained by him only six years since; and yet this generalization, apparently, at the time, only of abstract interest, entirely remote from practical application, produced as fruit the three most original, and, I think, the most important, practical discoveries of the Exhibition.

Having thus introduced the subject of his Lecture, Dr. Playfair proceeded to offer certain examples of *allotropism*. It had long been known that bodies crystallized in two or more incompatible forms. Thus, carbonate of lime as arragonite crystallizes in prisms; whereas as calcareous spar it crystallizes in rhombs. Sulphur also crystallizes in two incompatible forms; so does the garnet. This is termed *dimorphism*. When two such forms exist they are found to be maintained in unequal stability; it appears, in fact, as if one form was normal, and the other forced or strained. Thus a prism of arragonite is subject to change into rhombs of calc spar; and sulphur crystallized by heat in oblique rhombic prisms passes in a few days into a mass of rhombic octohedrons. Not only may the chemical and physical characteristics of such dimorphous bodies

differ, but their colour and their specific gravity. Thus, the sulphuret of iron ($Fe. S_2$), when crystallized in cubes, is persistent in the air; but when occurring in a rhombic form, readily passes into copperas or sulphate of iron.

Applying the preceding remarks to non-crystallized bodies, it was equally found that many were susceptible of allotropic modification. Thus cinnabar and vermilion were of precisely similar chemical composition with the black sulphuret of mercury. Again, the sesqui-sulphuret of antimony might be black or orange. Iodide of mercury is commonly red; when heated, however, it passes into a yellow powder, which by simple pressure and rubbing with a hard body becomes red again. Sugar is a remarkable instance of a solid capable of assuming two allotropic states; as sugar candy it is crystallized, as barley sugar it is amorphous; yet the composition of sugar in either case is the same. Nor are liquids exempt from the strange state of allotropism,—sometimes indeed manifesting a condition even beyond allotropism (*isomerism*), and not allowing us to reconvert them to their primitive state. Thus the chemical composition of oil of turpentine, of rosemary, of lemons, of copaiba, are identical, yet no one of these bodies has hitherto been turned into the other. The steroptane of otto of roses is identical in composition with coal gas, yet chemists are unable to change one into the other. The term isomerism has been commonly employed in relation to bodies of like atomic composition, and has reference to equality of parts. The term allotropism is a better denomination, and has referencc to the condition of unlike properties.

The preceding remarks by Dr. Playfair were introductory to an exposition of the respective discoveries of Mr. Mercer, Mr. Young, and Dr. Schrötter.

A.—Mercer's process consists in bringing cotton fabrics in contact with a solution of soda (cold), or a solution of dilute sulphuric acid, by subjecting it to either of which processes cotton acquires certain remarkable properties. In the first place, the texture becomes very much corrugated, and hence proportionably finer; it also assumes acid properties, rendering it more capable of taking up dyes. The process of induction which led Mr. Mercer to his final discovery was curious. He started from the point of investigating the laws which determined the flow of water at various temperatures through minute tubes. From water he proceeded to aqueous saline solutions; from tubes he proceeded to their equivalent, namely, closely-folded woven tissue. Selecting for this purpose a thick reduplication of calico, fold on fold, and employing an aqueous solution of soda, Mr. Mercer found that, by passing the solution through thc calico, soda was removed. This removal he attributed to the act of filtration; but, subsequently finding that mere immersion of the calico in the same solution effected a like result, he concluded that the result was due to an actual combination of the cotton with the soda—a calico-*ate* of soda (if the lecturer might bc permitted that form of expression) was generated.

The result of this agency of soda was, as formerly remarked, a physical corrugation, and an acquisition of certain chemical qualities. The former change was evident to the eye. Dr. Playfair exhibited two stockings, one of which being nearly double the size of the other, although both came equal in size from the loom. The difference had been occasioned solely by chemical not mechanieal agency. Dr. Playfair, in developing the numerous practical applications of this physical effect, showed that, besides the most obvious one of producing a material of increased fineness, the cotton thus prepared was far more capable of being dyed. Hot soda solution would not answer; and this fact was remarkable and had its analogue in those salts which deposited themselves anhydrous on boiling. Instead of soda sulphuric acid might be employed; in which case it formed, in combination with the cotton fibre, an easily decomposable conjugate acid.

B.—Some years ago Liebig stated that one of the greatest discoveries of chemistry would consist in converting coal-gas into a solid form, thus enabling it to be burned like a candle. This had, in a manner, been accomplished by Mr. Young. About three years since, Dr. Playfair drew the attention of Mr. Young to a spring of mineral oil, containing paraffine, and occurring in a coal-mine in Derbyshire. The liquid had been extensively applied by Mr. Young as a lubricating agent; a use which Reichenbach had long ago suggested. After a period, however, this spring ceased to flow, when Mr. Young applied himself to an investigation of the theoretical conditions under which it might be artificially formed. This gentleman saw that it would be difficult to convert gas into an allotropic form, whereas it was evident that gas must first come from a solid; hence he hoped to succeed in procuring the body before it assumed its gaseous state.

The illuminating portion of coal gas consists chiefly of olefiant gas, and the latter is isomeric with solid paraffine. But the allotropism does not end here; the peculiar slow distillation of coals yielding solid paraffine, also yielded another isomeric or allotropic compound in the form of a lubricating oil, besides the additional products of a burning oil, and naphtha.

Dr. Playfair now explained, by the aid of a diagram, the slow distillation process of Mr. Young, employed in generating his allotropic form of olefiant gas, and directed the attention of his audience to some candles made of coal paraffine on the lecture table.

C.— Schrötter's process of manufacturing amorphous or allotropic phosphorus was the third in Dr. Playfair's series. The properties of phosphorus in its ordinary condition are well known. It is spontaneously inflammable and highly poisonous; whereas the amorphous or allotropic phosphorus is neither spontaneously inflammable nor poisonous. Hence its great use in the manufacture of lucifer and congreve matches; an operation which not only imperilled the premises wherein it is conducted, but also the lives of those conducting it, causing the most frightful and fatal disease of the jaws and facial bones.

Common phosphorus, when heated to about 460 or 480, changes

into the allotropic condition, but a slight increment of heat changes it back again. Hence the manufacture of this substance on a large scale is attended with difficulties which Dr. Playfair had no doubt would be eventually overcome by the energy of Mr. Sturge the patentee. The specific gravity of ordinary phosphorus is 1.77 — of amorphous phosphorus, 1.964. Common phosphorus is soluble in bi-sulphuret of carbon, whereas the amorphous variety is not. Common phosphorus bursts into flame when brought into contact with iodine, whereas the amorphous or allotropic variety does not. Common phosphorus is luminous at very low temperatures, whereas the amorphous variety only commences to be luminous at a temperature of 500° F. In forming lucifer matches by means of allotropic phosphorus, there is experienced the difficulty that it does not ignite by friction ; hence it has to be mixed either with chlorate of potash, oxide of lead, or sulphuret of antimony, when friction takes effect and generates flame.

Having thus discussed the experimental portion of his lecture, Dr. Playfair concluded as follows : —

These three practical discoveries, for I think they are entitled to be considered as such, and not merely as inventions, have emanated from men all highly educated in chemical science. It is a proud subject of praise and of congratulation, that the two first discoverers, Mr. Mercer and Mr. Young, have, by the aid of science, raised themselves from the position of working artizans to that of employers in works involving considerable capital in their prosecution. Science has been to them a true power, the more so as in the arts which they profess, the manufacturers have usually been men of technical and not of scientific knowledge. The very fact of their success is a convincing evidence of what an immense development our industry might receive, if its sons were able to take advantage of the knowledge which science is constantly showering down upon the world.

There is a wide chasm between the laboratory of the philosopher and the workshop of the manufacturer — a chasm which must be bridged over by those who understand the nature of the foundations on either side. In general it is not the duty of the philosopher to do this ; it is more important for social progress, that he should continue to benefit the world by new accessions of truth, leaving to others to apply them to the promotion of the comforts and happiness of the human race. If technical men become disciples of science, then their acquaintance with the wants and requirements of manufacturers would enable them to derive from its teachings the knowledge requisite to apply it to the desired ends. Science should roll on, as it does now, a mighty river, from the abundant waters of which streams may be derived to fertilize the lands over which they pass ; for in the course of nature, these overflowings are restored in the form of refreshing showers. Their beneficial effects will however depend upon the skill of those who

construct the channels destined to direct the waters for the uses of industry.

It is no new truth that science should always be ready to benefit industry by instructing those engaged in it, rather than by directly uniting with it. This truth is as old as the mythology, where we find no celestial so beneficent to industrial arts as Minerva, although she always preserved an independent existence, notwithstanding the passionate wooing of Vulcan, the god of industry. We have had it inculcated by the sages of all countries, strongly enforced by our own Bacon, and eloquently advocated in the theatre of this Institution by Davy.

Abstract science could not, if it would, cause itself and industry to progress satisfactorily by means of its discovering philosophers. There must be other means of conveying its God-born truths to industry, in order to freshen and invigorate its existence. The results of continental success indicate that the true way for those requiring aid is to come to the fountain of knowledge and take that which they need.

I need not detain you longer on this subject, except again to urge you to consider what must be the result of the system of instruction pursued abroad. In addition to many provincial schools, France has two central colleges of arts and manufactures, in one of which 300 of the best youth of France commence their education in science just where our colleges leave off, and after two years, they are poured into the provinces to impart to industry the principles of science which they have there attained. Prussia, Austria, Russia, and the Northern States are encouraging the same kind of education, and even yet more extensively. Need we be surprised, then, that they are progressing so rapidly in manufactures, in spite of their dear fuel and machinery. Recollect that we *have* reached that state when in future the *competition of industry must be a competition of intellect.*

Is England in a prepared state to meet this intellectual competition? Have we adapted the system of instruction in our schools to the wants and necessities of the age? Has science, or a knowledge of God's works and God's goodness and wisdom, yet become an important part of the instruction of our sons of industry, or, do we not, by an antiquated notion, preserve the idea that the classical learning of the thirteenth century is all-sufficient for the requirements of the nineteenth century?

These questions are truly important if we desire to see England keep her ground in the industrial struggle of nations. I wish not to underrate any branch of human learning; but I do vehemently desire to see banished from our schools the bed of Procrustes, to the dimensions of which our children are clipped or extended until they are so changed in their natural aspirations for science, that it is very difficult, in after life, to communicate that amount which is necessary for its application to industry. I need not say, therefore, that until scientific instruction be added to the general system of education of our youth, that England cannot expect to be foremost in the industrial race of nations.

Already we see our capital largely employed to import foreign talent into our manufactures, and by this, in many cases, we retain our superiority. But it does not require much acumen to perceive the wretchedness of this policy as regards the nation, which, careless of the education of her own sons, sends her capital as a premium to the advancement of that intellectual knowledge in foreign states, who use it as the means of her destruction.

Excuse me if I have expressed my convictions on these points more strongly than you feel them; but they have taken such strong hold on my mind, that I cannot see safety for the future of our nation unless by a great and comprehensive improvement in the instruction of her people. I shall conclude in the language of Davy, when he addressed you on the benefits conferred by this Institution both on science and on industry: —

"There is no country which ought so much to glory in the progress of science as this happy island. Science has been a prime cause of creating for us the inexhaustible wealth of manufactures; and it is by science that it must be preserved and extended. We are interested as a commercial people; we are interested as a free people. The age of glory of a nation is also its age of security. The same dignified feeling which urges men to gain dominion over nations, will preserve them from the dominion of slavery. Natural, and moral, and religious knowledge are of one family; and happy is the country, and great its strength, where they dwell together in union." [L. P.]

In the Library were exhibited: —

Specimens of Corals and Madrepores; Iodide of Morphia, Gadolinite, and Sulphate of Strychnia. [Exhibited by T. N. R. Morson, Esq. M.R.I.]

Specimens of Fossil Wood from eight different strata, and a Sword from Assam. [Exhibited by Dr. Roxburgh, M.R.I.]

Large Stereoscopic Talbotype Views of the Interior of the Great Exhibition by Wheatstone's Improved Reflecting Stereoscope. [Exhibited by Mr. Henneman.]

Views of the Interior of the Great Exhibition, and of the Niagara Falls — and Portraits of Professors Brande and E. Forbes, Dr. Mantell and others, Daguerreotyped by Mr. Mayall.

Chinese Carving in Tree-Roots — Dog and Monkey. [Exhibited by Mr. Sichart.]

Nassau Candelabrum in Silver by Messrs. Hunt and Roskell.

Carvings in Wood, — Dead Larks — Group of Dead Animals — Cherub's Head in Box-wood, by Mr. W. G. Rogers.

Gems: Diamonds — A Large Emerald, (the property of the Duke of Devonshire) — Sapphire, Topaz, &c. — and a Model of the Koh-i-noor. [Exhibited by Mr. Tennant.]

Models of Moore's Patent Glass Ventilator, by Messrs. Moore.

Drawing in Water Colours — Hall Sands, Devon, by G. Barnard, Esq.
Microscopes by Messrs. Varley.

In the Ante-room were exhibited : —

A Model of a Martello-tower, near Genoa, constructed for the Drawing Classes at Rugby School, by Mr. G. Barnard, from Sketches made on the spot; and Drawings made from the Model by his Pupils.

GENERAL MONTHLY MEETING,

Monday, March 1, 1852.

Sir John P. Boileau, Bart., F.R.S., Vice-President, in the Chair.

Samuel Gaskell, Esq.
Robert S. W. Lutwidge, Esq.
Alfred James Woodhouse, Esq.

were *admitted* Members of the Royal Institution.

J. G. Appold, Esq.
Rev. J. Brownbill.
Octavius Browne, Esq.
George Edward Dering, Esq.
George Field, Esq.
Matthew Flower, Esq.
Lieut.-Colonel Francis Vernon Harcourt.
Thomas Henry, Esq.
Abel Jenkins, Esq.
Francis Lloyd, Esq.
Charles Lyall, Esq.
Kenneth Macaulay, Esq., Q.C.
George Whitlock Nicholl, Esq.
Rev. C. Pritchard, M.A., F.R.S.
Samuel Tomkins, Esq.
Edward Owen Tudor, Esq.

were duly *elected* Members of the Royal Institution.

The Secretary reported that the following Arrangements had been made for the Lectures after Easter, viz. : —

Eight Lectures on the History and Practice of Sculpture, by R. Westmacott, R.A.

Eight Lectures on the Physiology of Plants, by Dr. E. Lankester, F.R.S.

Six Lectures on Points connected with the Non-Metallic Elements — by Professor Faraday.

The following Presents were announced; and the thanks of the Members returned for the same : —

From
Astronomer-Royal. — Astronomical and Magnetical and Meteorological Observations at Greenwich in 1850. 4to. 1852.

Astronomical Society (Royal) — Memoirs, Vol. XX. 4to. 1851.
Monthly Notices, Vol. XI. 8vo. 1851., and Vol. XII. No. 2 & 3. 8vo. 1852.
Bell, Jacob, Esq. M.P. (the Editor) — The Pharmaceutical Journal for Feb. 1852.
Botfield, Beriah, Esq., F.R.S., F.S.A., M.R.I. (the Editor). — Original Letters relating to the Ecclesiastical Affairs of Scotland, 1603 — 1625. 2 vols. 4to. 1851.
Institute of British Architects (Royal). — Proceedings, Feb. 1852. 8vo.
Institute of Civil Engineers — Proceedings, Feb. 1852. 8vo.
Commissioners in Lunacy — Sixth Annual Report. 8vo. 1851.
Society of Dilettanti — An Investigation of the Principles of Athenian Architecture, &c., by F. C. Penrose, Architect, M.A. Folio. 1851.
Editor — The Athenæum for Jan. 1852. 4to.
Editor — The Chemical Record for February, 1852. 8vo.
Faraday, M. Esq. (the Author) — Experimental Researches in Electricity. 28th Series. 4to. 1852.
Kaiserliche Akademie zu Wien: *Phil.-Hist. Classe:* —
Denkschrifte, 2te Band, 2te Abtheilung. 4to. 1851.
Sitzungsberichte, 6te Band und 7te Band, Heft 1 und 2. 8vo. 1851.
Die Alterthümer vom Halstätter Salzberg: von F. Simony. obl. fol. 1850.
Archaelogischen Analecten, von Joseph Arneth. obl. fol. 1851.
Math.-Nat. Classe: —
Denkschrifte, 2te Band, 3te Abtheilung. 4to. 1851.
Sitzungsberichte, 6te Band und 7te Band, 1te und 2te Hefte. 8vo. 1851.
Archiv für Kunde Œster. Geschichts-Quellen, 5te Band, 3te und 4te Hefte; und 6te Band. 8vo. 1850-1.
Fontes Rerum Austriacarum, 4te Band. 8vo. 1851.
Notizenblatt, No. 2 — 18. 8vo. 1851.
Atti dell' Academia Ponteficia de' Nuovi Lincei, Anno IV. Sess. 5, 6. 4to. 1851.
Monatsberichte der Königl. Preuss. Akademie zu Berlin, Nov. und Dec. 1851. 8vo.
Geological Society — Quarterly Journal, No. 29. 8vo. 1852.
Jopling, Joseph, Architect (the Author) — An Impulse to Art, or Ancient Greek Principles for Volutes, &c. and Examples of Entasis. 8vo. 1848-9.
Lawson, H., Esq., F. R. S. — The Thermometer-Stand. 8vo.
Lovell, E. B., Esq., M. R. I. (the Editor) — The Monthly Digest. Feb. 1852.
Manning, F., Esq., M.R.I. — Account of the Kenilworth Buffet with elaborately carved relievos, illustrative of Kenilworth Castle in the Elizabethan Period, designed and manufactured by Messrs. Cookes and Sons, Warwick, for the Grand Exhibition of 1851. 4to. 1851.
Newman, Mr. J. — Instructions for using Newman's Standard and Portable Barometers and Daniell's Hygrometer. 8vo. 1845-52.
Neale, Edward Vansittart, Esq., M. R. I. (the Author) — "May I not do what I will with my own?" Considerations on the Present Contest between the Operative Engineers and their Employers. 12mo. 1852.
Prince, C. Leeson, Esq. (the Author) — Results of a Meteorological Register kept at Uckfield, Sussex, for 1851.
Statistical Society of London — Journal, Vol. XIV. Part 4. 8vo. 1852.
Vereins zur Beförderung des Gewerbfleisses in Preussen — Verhandlungen, Nov. und Dec. 1851.
Vincent, B. (Assist. Sec. R. I.) — Histoire de la Guerre de Sept Ans en Allemagne de 1756 à 1763, par M. J. W. D'Archenholtz: traduite de l'Allemand, par M. D'Arnex. 12mo. Berne, 1789.
The North American and West Indian Gazetteer. 12mo. 1776.

Bollaert, W. Esq. — Specimens of Native Salts from Tarapaca, Peru.